PATENT SPECIFICATION

(11) 1376513

1376513

(21) Application No. 42691/72 (22) Filed 14 Sept. 1972
(23) Complete Specification filed 18 July 1973
(44) Complete Specification published 4 Dec. 1974
(51) International Classification G01V 1/38
(52) Index at acceptance
H4D G3A G4A5 G7P
(19)

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(54) MARINE SEISMIC PROSPECTING

(71) We, IMPERIAL CHEMICAL INDUSTRIES LIMITED, Imperial Chemical House, Millbank, London SW1P 3JF, a British Company, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The invention relates to a method of marine seismic prospecting which is especially advantageous for prospecting areas under ice-covered water and to apparatus for use in the method.

Marine seismic prospecting is the term generally applied to methods of seismographic prospecting of water covered areas. In marine prospecting, seismic pressure waves are generated from a source, commonly an explosive source, in the water and the waves, after reflection or refraction from underwater strata interfaces, are recorded and interpreted to produce a record of the shape of the underwater rock layers. In order to reduce unwanted pulses resulting from oscillations in spherical bubbles of gaseous products from explosive charges fired below the 'blow out' depth, the charge is usually an elongated condensed (non-gaseous) explosive charge having a length to diameter ratio of at least 10:1 as described in United Kingdom Patent Specification No. 1097420. Thus in one system for seismic prospecting the explosive charge is used in the form of a detonating fuse-cord having a thin core of powdered high explosive in a waterproof sheath. However, even with long explosive charges a spurious or 'ghost' signal arises from the reflection of upward pressure waves at the surface of the water and this signal complicates the interpretation of the seismograph records.

It is now propsed to extend marine seismic prospecting operations to arctic regions where the water is covered by ice and to generate the seismic waves and record them in the same manner as hiterto, the generation of the seismic pressure waves and the placing of the recording hydrophones being done from a moving submarine.

It has been found, however, that when the seismic pressure waves are generated by firing a condensed explosive charge in water under ice, the amount of unwanted pressure waves reaching the hydrophones is much greater than when water only is present and the interpretation of the records becomes much more difficult. Such spurious waves result from reflection of waves from the lower surface of the ice which is often uneven so that waves are not only reflected from the surface in the area immediately above the hydrophones but also from ice ridges further away.

Also, the explosive charges placed from a submarine under ice are usually placed at depths of 70 metres or more compared to 6 to 10 metres for charges in ice-free water, with the result that the 'ghost' signal from the ice surface arrives at the recorder much later and therefore causes more confusion of the record.

Other spurious waves arise from the oscillation of the ice layer consequent on the generation of pressure waves from the explosive charge.

It is an object of this invention to reduce the amount of upward seismic waves generated from a condensed explosive charge in marine seismic prospecting being reflected to the wave detectors.

We have now found that the effect of the reflection of the upward seismic waves at water boundaries above the explosive charge can be markedly reduced by gas disposed above the explosive charge so that it intervenes between the charge and the reflective boundary.

Thus, in accordance with this invention, in a method of marine seismic prospecting wherein seismic pressure waves are generated by the explosion underwater of a condensed explosive charge and are recorded after reflection or refraction from an underwater rock layer interface to provide a record of the underwater rock structure, a mantle of gas is disposed

[*Price 25p*]

between the explosive charge and the water surface, whereby pressure waves proceeding upwards from the explosive charge are attenuated and/or scattered. The employment of gas in this manner substantially reduces the unwanted 'ghost' signal resulting from reflection of pressure waves from the upper water boundary, whether at an air or ice layer, and, where the water is covered by ice, the method is especially advantageous in reducing the waves reflected from the ice and also the waves resulting from the oscillation of the ice layer consequent on the generation of the seismic pressure waves.

When the explosive charge is towed behind a moving boat, the means to provide the gas may also be towed by the boat.

In one convenient procedure, gas bubbles are released near to the explosive charge to form a mantle of bubbles above the charge. The bubbles may, for example, be released from one or more perforated dispensing pipes disposed in the water. Such pipes should preferably be placed as near the explosive charge as possible but at a sufficient distance to avoid damage thereby.

The gas may also conveniently be provided in the form of a foam, for example as closed-cell foamed waterproof plastics material. In this form, a sheet of foamed plastics, for example closed-cell foamed polyurethane or polystyrene may conveniently be disposed as a flat or curved sheet over the explosive charge. The foamed plastics should preferably be perforated to permit the escape of any gaseous products which become entrapped below it.

In a futher manner of practising the gas may conveniently be contained in an inverted vessel disposed above the seismic wave source. In this method the gas is advantageously gas which has been produced from a previously exploded explosive charge and entrapped in the vessel.

Whilst any convenient solid or liquid explosive charge may be used to generate the seismic waves, the preferred charges are the aforementioned elongated charges, for example detonating cord.

The invention also includes apparatus for marine seismic prospecting comprising a boat, for example a submarine, provided with means to place a condensed explosive charge underwater to generate seismic waves, means to record said seismic waves after reflection or refraction from an underwater rock layer interface, and means to dispose a mantle of gas, for example gas bubbles or foamed plastics, between the explosive charge and the water surface.

In order to illustrate the invention further, the practice of the invention in marine seismic prospecting on ice-covered prospect areas is hereinafter described with reference to the accompanying diagrammatical non-scalar drawings, wherein

Fig. 1 shows in perspective, partly in section, a submarine towing an explosive charge before the charge is fired in a marine prospecting operation,

Fig. 2 is a modification of the arrangement of Fig. 1.

In the arrangement shown in Fig. 1 a cord explosive charge 10 is attached by a connector 11 to a firing cable 12 by which it is towed by a submarine 13 moving in water 14, under an ice layer 15 and over an underwater rock mass 16. An air pipe 17 from a compressed air source in the submarine 13 delivers a stream of air bubbles to form a mantle of bubbles 18 above the charge 10. A tubular streamer 19 containing hydrophones is also towed by the submarine.

When the explosive charge is fired the downward seismic pressure waves are reflected at rock layer interfaces in the rock 16 and detected and recorded by means of the hydrophones. The unwanted upward pressure waves are attenuated or scattered by the air bubbles 18 and the spurious signals reaching the hydrophones after reflection from the ice layer 15 are accordingly much less than would be the case if the charge were fired in the absence of the air bubbles.

In the arrangement of Fig. 2 a canister charge of explosive 20 is attached by a connector 11 to the firing cable 12 and towed by submarine 13. A dome 21 of closed-cell foamed plastics material is disposed over the charge 20 and also towed from the submarine 13. Gaseous products from the charge 20 escape through the holes 22 in dome 21.

When the charge 20 is detonated the upward pressure waves are attenuated and scattered by the air bubbles in sheet 21 so that unwanted pressure waves reaching the hydrophones after reflection from the ice layer 15 are markedly reduced.

WHAT WE CLAIM IS:—

1. A method of marine seismic prospecting wherein seismic pressure waves are generated by the explosion underwater of a condensed explosive charge and are recorded after reflection or refraction from an underwater rock layer interface to provide a record of the underwater rock structure, in which method a mantle of gas is disposed between the explosive charge and the water surface whereby pressure waves proceeding the explosive charge are attenuated and/or scattered.

2. A method as claimed in Claim 1 wherein the water is covered by ice.

3. A method as claimed in Claim 1 or Claim 2 wherein gas bubbles are released near to the explosive charge to form a mantle of bubbles over the charge.

4. A method as claimed in Claim 3 wherein the gas bubbles are released from one or more perforated dispensing pipes disposed in the water.

5. A method as claimed in Claim 1 or Claim 2 wherein the gas is provided in the form of a foam.

6. A method as claimed in Claim 5 wherein the foam is in the form of a closed-cell foamed waterproof plastics material.

7. A method as claimed in Claim 6 wherein the foamed plastics material is in sheet form.

8. A method as claimed in Claim 6 or Claim 7 wherein the foamed plastics material comprises foamed polyurethane or foamed polystyrene.

9. A method as claimed in any one of Claims 6 to 8 wherein the foamed plastics material is perforated to permit the escape of gaseous products which become entrapped below it.

10. A method as claimed in Claim 1 or Claim 2 wherein the gas is contained in an inverted vessel disposed over the explosive charge.

11. A method as claimed in Claim 10 wherein the gas is gas which has been produced from a previously exploded explosive charge and entrapped in the vessel.

12. A method as claimed in any one of Claims 1 to 11 wherein the condensed explosive charge comprises an elongated explosive charge having a length to diameter ratio of at least 10:1.

13. A method as claimed in Claim 12 wherein the explosive charge comprises detonating cord.

14. A method of marine seismic prospecting substantially as herein described with reference to the accompanying drawings.

15. An apparatus for marine seismic prospecting comprising a boat provided with means to place a condensed explosive charge underwater to generate seismic waves, means to record said seismic waves after reflection or refraction from an underwater rock layer interface, and means to dispose a mantle of gas between the explosive charge and the water surface.

16. Apparatus as claimed in Claim 15 wherein the boat is a submarine vessel.

17. Apparatus as claimed in Claim 15 or Claim 16 wherein the gas disposal means comprises a gas bubble source.

18. Apparatus as claimed in Claim 17 wherein the gas bubble source comprises one or more perforated gas dispensing pipes.

19. Apparatus as claimed in Claim 15 or Claim 16 wherein the gas disposal means comprises foamed plastics material.

20. Apparatus for marine seismic prospecting substantially as herein described with reference to the accompanying drawings.

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Printed for Her Majesty's Stationery Office, by the Courier Press, Leamington Spa, 1974.
Published by The Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.

1376513 COMPLETE SPECIFICATION

1 SHEET *This drawing is a reproduction of the Original on a reduced scale*

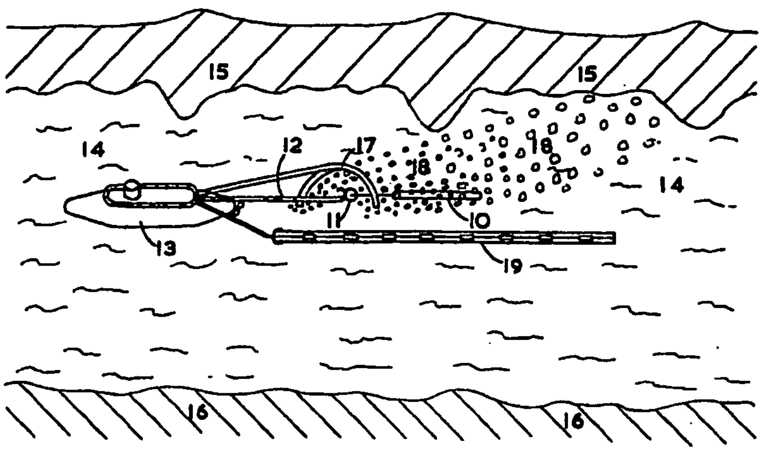

FIG. 1

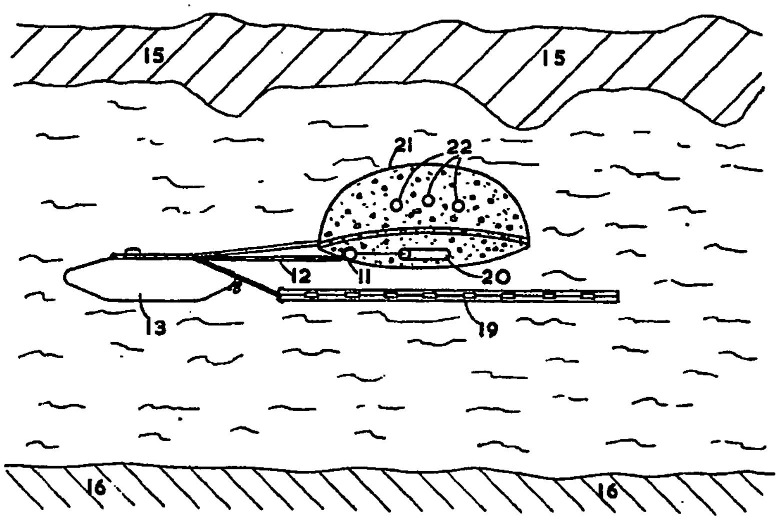

FIG. 2

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